Changes in *Neomysis mercedis* Fecundity in the Upper Estuary Since 1979

POD Element 2C

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Changes in gravid female length

There has been no change in mean length of gravid female *N. mercedis*, but shorter and longer individuals are no longer appearing in the catches.

Changes in fecundity

The number of gravid females available for analysis has been declining since 1988 (Table 1). Many of the monthly values since 1992 are based on fewer than 10 individuals.

There has been no apparent change in fecundity (number of eggs per gravid female) by length and embryo stage (Figure 1). *Neomysis mercedis* fecundity increases with length. Beginning in 1998, the upper estuary has had a reduction in the relative number of longer (greater than or equal to 14 mm) females (Figure 2). This decline in the number of longer females causes the illusion that the mean number of embryos per female has declined.

Fecundity by region

Until 2003, the highest mean fecundity occurred during spring in Suisun Bay (Figure 3). Since 2003, the Sacramento and San Joaquin Rivers have had the highest fecundity. In summer and fall fecundity has been more evenly distributed over the upper estuary but has been lowest in the South Delta. There has been no significant change in the summer and fall distribution.

Fecundity by electro-conductivity

The distribution of electro-conductivity has been relatively stable over the years (Figure 4)

The upper estuary was divided into 10 electro-conductivity (ec) classes which had approximately the same number of samples (Table 2).

Until about 1994, the spring and summer, fecundity was spread relatively evenly through all ec classes (Figure 5). In high flow years (1982, 1983, 1995, 1997, 1998, and 1999) the higher ec classes did not occur in the sampling area and therefore fecundity artificially appears to be lower than the other years. Since 1994, spring fecundity has been highest in ec classes 3 to 5 and summer fecundity highest in ec classes 1 to 3. The subsequent low mean fecundity may be due to the absence of the larger, more fecund females. The fall fecundity was highest in ec classes 4 to 9 until about 1990. Since 1990, fall fecundity has been declining with the exception of a period from 1997 to 2001.

Changes in the percent of females which are gravid

The percent of females which are gravid (percent gravid) has not changed uniformly since 1976 (Figure 6). All months from March through November except April have shown declines in the percent gravid but these declines did not start in the same years for each month. The presence of gravid females in March became sporadic in 1986 and has been seen in only one year (1997) since 1993. Gravid females were seen in April every year until 1998. Since then the presence of gravid females has been sporadic. The presence of gravid females in May became sporadic in 1997. Gravid females have been detected in June of every year since 1976. In July, the gravid females have appeared sporadically since 1994. For August through November gravid females have been seen sporadically since 1993. For March through November combined, there is a small and insignificant downward trend (Figure 7). The pattern of the residuals of this trend is not random ($p=0.01$) (Figure 8).

Percent gravid by region

Prior to 1990 the percent gravid was more or less evenly distributed around the upper estuary during all seasons (Figure 9). Since 1990, the percent gravid has been higher in the South Delta during spring, in the San Joaquin River and Suisun Bay during summer and fall. Suisun Marsh also is relatively high during fall. In general, the percent gravid has been lower between 1991 and 2004 than it was prior to 1991.

Percent gravid by electro-conductivity

In spring the highest percent gravid values occur between ec classes 3 and 6 (Figure 10). Prior to 1990 high percentages of gravid females also occurred classes 1 and 2 as well as classes 6 and 7. Since 1990, high values of percent gravid occur only sporadically. Until about 1991 summer high percent gravid occurred from classes 1 through 8. Summer percent gravid figures have been sporadic since 1991. From 1979 to 1984 relatively high percent values occurred in ec classes 3 through 10. After 1985, the percent gravid levels for fall declined in the lower ec classes and is now concentrated in ec classes 5 through 10. There was a period or particularly low percent gravid levels from 1993 to 1996.

Further investigation should be carried out to determine whether the low levels of gravid females is due directly to environmental factors such as lack of food or the presence of certain toxins or indirectly as a result of the lower densities which may make it more difficult for females to find mates. The cause of the low numbers of longer females should also be investigated.

Table 1
Number of Gravid Female *Neomysis mercedis* Processed
Each Year by Month

Year	Month									Total
	March	April	May	June	July	August	September	October	November	
1979	199	385	432	355	263	202	188	237	131	2392
1980	148	322	374	388	399	291	309	269	162	2662
1981	159	256	352	285	221	166	126	134	77	1776
1982	133	88	132	256	413	208	214	174	15	1633
1983	21	119	87	133	97	121	138	82	19	817
1984	102	165	261	145	139	201	75	49	31	1168
1985	153	193	212	194	193	228	150	106	30	1459
1986	0	133	177	174	187	170	190	114	48	1193
1987	212	252	234	159	108	144	58	107	41	1315
1988	43	209	237	161	0	108	34	40	9	841
1989	43	142	160	204	94	61	30	69	21	824
1990	46	118	196	54	62	71	16	1	1	565
1991	20	124	149	115	67	50	11	0	14	550
1992	0	129	114	52	13	0	5	7	9	329
1993	5	19	73	79	4	3	0	0	0	183
1994	0	24	2	27	1	0	0	0	0	54
1995	0	23	5	3	4	0	0	0	0	35
1996	0	2	1	6	2	0	0	0	0	11
1997	6	14	1	9	0	0	0	0	0	30
1998	0	0	6	7	0	0	0	0	0	13
1999	0	1	4	15	0	0	3	0	0	25
2000	0	6	25	4	0	0	0	0	0	35
2001	0	4	27	2	0	0	0	0	0	33
2002	0	0	0	2	0	0	0	0	0	2
2003	0	0	0	0	3	0	0	0	0	3
2004	0	0	5	1	1	0	0	0	0	7

Table 2
Electro-conductivity Class Ranges and Means

Electro-conductivity Class	N	Minimum (μ Semens/cm)	Mean (μ Semens/cm)	Maximum (μ Semens/cm)
1	1994	24	79.20	233
2	1980	234	369.99	533
3	1981	535	761.70	1066
4	1993	1068	1427.49	1840
5	2003	1845	2384.10	2891
6	1983	2913	3643.20	4330
7	1970	4356	5377.11	6362
8	1987	6364	7570.20	8745
9	1972	8755	10421.57	12168
10	1819	12190	15348.53	30159